

IN THE CLAIMS:

1. (Currently Amended) A method for generating and detecting ultrasonic surface displacements on a remote target comprising the steps of:

directing a first pulsed laser beam to illuminate a portion of a surface of the remote target with an optical assembly;

generating using a first pulsed laser beam to generate ultrasonic surface displacements within the illuminated portion of on a the surface of the remote target with the first pulsed laser beam;

directing a second pulsed laser beam substantially to the illuminated portion of the surface of the remote target, wherein the first pulsed laser beam and second pulsed laser beam are directed to the surface of the remote target with ;

detecting, using the a second pulsed laser beam coaxial with said first pulsed laser beam, to detect the ultrasonic surface displacements substantially within the illuminated portion of on the surface of the remote target;

collecting phase modulated light from the second pulse laser beam either reflected or scattered by the remote target; and

processing the phase modulated light to obtain data representative of the ultrasonic surface displacements on the surface of the remote target; and

processing the data representative of the surface displacements to assess the structural integrity of the remote target.

2. (Currently Amended) The method of Claim 1 wherein the step of processing the phase modulated light further comprising the steps of:

using an interferometer stabilized with the phase modulated light to demodulate the phase modulated light for creating at least one optical signal;

converting the at least one optical signal into at least one digital signal; and

using a digital signal processor to process the at least one digital signal.

3. (Original) The method of Claim 2 wherein the step of converting the at least one optical signal into at least one digital signal further comprising the steps of:

converting the at least one optical signal into at least one analog signal; and
converting the at least one analog signal into at least one digital signal.

4. (Currently Amended) [A] An apparatus for generating and detecting ultrasonic surface displacements on a remote target comprising:

a first pulsed laser to generate a first pulsed laser beam to illuminate a portion of a surface of the remote target and produce ultrasonic surface displacements substantially within the illuminated portion of the ~~on~~ a surface of the remote target;

a second pulsed laser to generate a second pulsed laser beam coaxial with said first pulsed laser beam, wherein the second pulsed laser beam substantially illuminates the portion of the surface illuminated by the first pulsed laser beam to detect the ultrasonic surface displacements on the surface of the remote target;

a scanning optical assembly operable to direct the first pulsed laser beam and second pulsed laser beam to the surface of the remote target;

collection optics, optically coupled to the scanning optical assembly, operable to collect ~~for collecting~~ phase modulated light from the second pulsed laser beam either reflected or scattered by the remote target;

an interferometer stabilized with the phase modulated light, wherein the interferometer is operable to process the phase modulated light and generate at least one output signal; and

a processor operable to:

process the at least one output signal to obtain data representative of the ultrasonic surface displacements on the surface of the remote target; and

process the data representative of the surface displacements to assess the structural integrity of the remote target.

5. (Original) The apparatus of Claim 4 further comprising an intensity controller to adjust on a pulse-by-pulse basis the intensity of the second pulsed laser beam in proportion to the intensity of the phase modulated light collected by the collection optics.

6. (Original) The apparatus of Claim 4 wherein the first pulsed laser emits a laser beam of coherent light of about 10 microns in wave length.

7. (Original) The apparatus of Claim 4 wherein the interferometer is self-stabilized using substantially 100% of the phase modulated light delivered to the interferometer by the collection optics.

8. (Original) The apparatus of Claim 4 further comprising an optical ranging unit to calculate a distance by which the remote target is separated from the apparatus.

9. (Currently amended) A large area composite inspection apparatus for measuring ultrasonic surface displacements on a surface of a remote target comprising:

a detection laser to generate a pulsed laser beam to detect the ultrasonic surface displacements on the surface of the remote target;

a scanning optical assembly operable to scan the pulsed laser beam across the surface of the remote target;

collection optics, optically coupled to the scanning optical assembly for collecting phase modulated light from the pulsed laser beam either reflected or scattered by the remote target;

an interferometer to process the phase modulated light collected by the collection optics, wherein the interferometer is stabilized with the collected phase modulated light either reflected or scattered by the remote target;

said interferometer comprising:

a first cavity having a first confocal lens structure; a second cavity having a second confocal lens structure; a device for dividing incoming de-polarized light into a first polarized light component and a second polarized light component wherein said device also directs said first and second polarized light components into the first and second cavities;

a control system to adjust said first and second cavities such that a ratio of light transmitted through each cavity to light reflected back through each cavity remains substantially constant; and

a processor to process the light transmitted through the first cavity, the light reflected back through the first cavity, the light transmitted through the second cavity, and the light reflected back through the second cavity, all in order to obtain data representative of the ultrasonic surface displacements on the surface of the remote target.

10. (Original) The large area composite inspection apparatus of claim 9 further comprising an intensity controller which adjusts on a pulse-by-pulse basis the intensity of the pulsed laser beam in proportion to the intensity of the phase modulated light collected by the collection optics.

11. (Original) The large area composite inspection apparatus of claim 9 further comprising a positioning apparatus to move the detection laser across the surface of the remote target and then record and index the data detected by the large area composite inspection apparatus.

12. (Original) The large area composite inspection apparatus of claim 9 wherein the positioning apparatus is a gantry positioning apparatus.

13. (Original) The large area composite inspection apparatus of claim 9 further comprising a generation laser to generate a pulsed laser beam to detect generate the ultrasonic surface displacements on the surface of the remote target.

14. (Original) The large area composite inspection apparatus of claim 9 wherein the generation laser and the detection laser coaxially apply laser beams to the surface of the remote target.

15. (Currently amended) A method for generating and detecting ultrasonic surface displacements in a remote target comprising the steps of:

generating ultrasonic surface displacements in the remote target;

directing a pulsed laser beam to detect the ultrasonic surface displacements on the surface of the remote target;

collecting light from the pulsed laser beam either reflected or scattered by the remote target;

processing the light collected from the remote target using an interferometer, wherein the interferometer is stabilized with the collected light;

said interferometer comprising: a first cavity having a first confocal lens structure; a second cavity having a second confocal lens structure; a device for dividing incoming de-polarized light into a first polarized light component and a second polarized light component wherein said device also directs said first and second polarized light components into the first and second cavities; a control system to adjust said first and second cavities such that a ratio of light transmitted through each cavity to light reflected back through each cavity remains substantially constant; and a plurality of detectors to detect the light transmitted through the first cavity, the light reflected back through the first cavity, the light transmitted through the second cavity, and the light reflected back through the second cavity, all in order to obtain data representative of the ultrasonic surface displacements on the surface of the remote target.

16. (Original) The method of claim 15 further comprising the step of adjusting on a pulse-by-pulse basis the intensity of the pulsed laser beam in proportion to the intensity of the light collected from the remote target.

17. (Original) The method of claim 15 further comprising the step of indexing the detection laser across a surface of the remote target and then recording the data on a point-by-point basis.

18. (Original) The method of claim 15 wherein the step of generating ultrasonic surface displacements in the remote target is accomplished a generation laser beam.

19. (Original) The method of claim 15 wherein the pulsed laser beam and a beam of the generation laser are coaxially applied to the surface of the remote target.

Rejections Under 35 USC § 102

Claims 1, 4 and 7 stand rejected under 35 U.S.C. § 102(a) as being anticipated by Klein, et al. The Examiner states that Klein, et al. “show an apparatus and method comprising: using a first pulsed laser beam (16) to generate ultrasonic surface displacements on a surface of the remote target; using a second pulsed laser beam (36) coaxial with said first pulsed laser beam to detect the ultrasonic surface displacements on the surface of the remote target; collecting (34) substantially 100% of phase modulated light from the second pulse laser beam either reflected or scattered by the remote target; and processing (48+) the phase modulated light to obtain data representative of the ultrasonic surface displacements on the surface of the remote target.”

Applicants respectfully submit that the second pulses laser beam (16) is applied to a surface opposite that of surface (40) upon which ultrasonic surface displacements are detected. Applicants respectfully submit that laser beam (16) and laser beam (36) are not applied coaxially to the same surface upon which ultrasonic surface displacements are generated and detected from. As shown in FIG. 1, ultrasonic displacements generated by laser beam (16) or transducer (22) are not necessarily generated on surface (40) of object (18) but rather another surface of object (18). In fact, as shown here, laser beam (36) is applied to surface (40) of object (18), while laser beam (16) or transducer (22) is applied to a second unnumbered surface of object (18) wherein the generation of the ultrasonic displacements by laser beam (16) or transducer (22) is not coaxial with laser beam (36).

The examiner further states in response to applicant’s argument that the “Klien does not show the first and second beam to be coaxial is unpersuasive. It is the opinion of the examiner that the first and second beam to share the same axis as shown by Figure 1. Although it is clear that the first and second beams do not share the same optical path. Furthermore as presently claimed “a surface” does not require the first and second beam to share the same surface of the target but rather only requires that any surface of the target.”

Applicants respectfully submit that amended Claim 1 directs the first pulsed laser beam to illuminate a portion of a surface of the remote target with an optical assembly. The ultrasonic surface displacements are generated substantially within the illuminated portion of the surface of the remote target. A second pulsed laser beam is directed substantially to the illuminated portion of the surface of the remote target. But in this instance unlike Figure 1 both the detection and

generation of both the first pulse laser beam and the second pulse laser beam illuminate substantially the same portion of the surface of the remote target.

Thus, one of the advantages provided by the instant application not afforded by Klien is “that the present invention does not require access to both sides of a composite structure to test for defects” (10/634, 342, Page 7, Lines 22-24).

With respect to Claim 7 wherein the examiner states that Klien provides for “collecting (34) substantially 100 percent of phase-modulated light when the second pulse laser beam either reflected or scattered by the remote target.” Applicants respectfully submit that this can be differentiated from Claim 7, wherein Claim 7 provides that the interferometer is self-stabilized using substantially 100 percent of the phase modulated light delivered to the interferometer by the collection optics as opposed to collecting 100 percent of the phase modulated light from the surface of the remote target.

Therefore, applicants respectfully submit that the present invention can be clearly distinguished from that of Klein, et al. in that Klien fails to teach that the generation and detection laser beams be applied to substantially the same location on the surface of the remote target. Therefore, Applicants respectfully request that the rejections under 35 U.S.C. § 102(a) be withdrawn and allow claims 1, 4 and 7.

Applicants appreciate the time taken by the Examiner to review Applicants’ present application. This application has been carefully reviewed in light of the Official Action mailed November 18, 2004. Applicants respectfully request reconsideration and favorable action in this case.

Rejections under 35 U.S.C. § 103

Applicants respectfully point out that in order to combine references for an obviousness rejection, there must be some teaching, suggestion or incentives supporting the combination. *In re Laskowski*, 871 F.2d 115, 117, 10 U.S.P.Q. 2d 1397, 1399 (Fed. Cir. 1989). The mere fact that the prior art could be modified does not make that modification obvious unless the prior art suggests the desirability of the modification. *In re Gordon*, 733 F.2d 900, 902, 221 U.S.P.Q. 1125, 1127 (Fed. Cir. 1984). In addition, it is well established that Applicant’s disclosure cannot be used to reconstruct Applicant’s invention from individual pieces found in separate, isolated references. *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q. 2d 1596 (Fed. Cir. 1988).

Claims 2 and 3 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Klein as applied to claim 1 above and further in view of Schultz et al (US 5,402,223). The examiner states:

Klein does not show the converting of the analog signals to digital signals. Schultz et al show a furnace control system using an interferometer comprising of converting the detection signals from analog to digital signals. At the time of the invention, one of ordinary skill in the art would have converted the analog signals to digital signals in order to electronically analyze the signals by a computer.

Applicants respectfully submit that there is no motivation, teaching or suggestion to combine Klien with Schultz. Therefore, the rejection on a combination of these references is inappropriate. Withdrawal of the rejection allowance of Claims 2 and 3 is respectfully requested.

Applicants further submit that neither Klien or Schultz alone nor the combination of the two teaches or suggests make obvious the invention recited in Claim 2 and 3 because the cited references fail to depict a generation laser beam and detection laser beam that share a common optical path.

Klien teaches away from the claimed invention. Klien does not require that the first and second beam illuminate substantially the same location on the surface of the target. The invention, as claimed in amended Claim 1 from which Claims 2 and 3 depend, require that the first and second beam illuminate substantially the same location on the surface. Schultz teaches a furnace controller that converts analog to digital signals. Therefore, the cited prior art teaches away from the Applicant's invention and fails to mention any such arrangement. This arrangement allows Applicants' invention to "not require access to both sides." (10/634,342, Page 7, Lines 22-24) Thus providing a significant advantage over the prior art.

Applicants, therefore, respectfully request the Examiner to reconsider and withdraw the rejection to allow Claims 2 and 3.

Claim 5 stands rejected under 35 U.S.C. 103(a) as being unpatentable over Klein as applied to claim 1 above, further in view of Siu et al (6,181,431). The examiner states:

Klein does not expressly show the intensity controller. Siu et al show ultrasonic evaluation system comprising a controlled pulsed laser. At the time of the invention, one of ordinary skill in the art would have used a controller for the laser in order to control the magnitude and pulse of the laser.

Applicants respectfully submit that there is no motivation, teaching or suggestion to combine Klien with Siu. Therefore, the rejection on a combination of these references is inappropriate. Withdrawal of the rejection allowance of Claim 5 is respectfully requested.

Applicants further submit that neither Klien or Siu alone nor the combination of the two teaches or suggests make obvious the invention recited in Claim 5 because the cited references fail to depict a generation laser beam and detection laser beam that share a common optical path, and that use the generation and detection laser beam to assess the internal structure of the remote target. Further, Siu teaches that the power of the laser used to generate the ultrasound may be controlled. This is done “to prevent material ablation” (Siu, Col. 6, Lines 33-34) The present invention adjusts the detection laser to improve the received signal.

Klien teaches away from the claimed invention. Klien does not require that the first and second beam illuminate substantially the same location on the surface of the target. The invention, as claimed in amended Claim 1 from which Claim 5 depends, requires that the first and second beam illuminate substantially the same location on the surface. SIU teaches that the generation laser may be adjusted to prevent material ablation, while applicants claim that the detection laser may be adjusted to improve the received signal. Therefore, the cited prior art fails to mention any such arrangement.

Applicants, therefore, respectfully request the Examiner to reconsider and withdraw the rejection to allow Claim 5.

Claim 6 stands rejected under 35 U.S.C. 103(a) as being unpatentable over Klein as applied to claim 1 above, further in view of Maris (5,706,094). The examiner states:

Klein does not expressly show the wavelength of the laser beam. Maris shows an ultrafast optical technique for the characterization of altered materials comprising of a pulsed laser source having a wavelength of

about 10 microns. At the time of the invention, one of ordinary skill in the art would have used a pulsed laser having a wavelength of about 10 microns since Klein is silent about the wavelength and Maris suggests that the wavelength should be about 10 microns.

Applicants respectfully submit that there is no motivation, teaching or suggestion to combine Klien with Maris. Therefore, the rejection on a combination of these references is inappropriate. Withdrawal of the rejection allowance of Claim 6 is respectfully requested.

Applicants further submit that neither Klien or Maris alone nor the combination of the two teaches or suggests make obvious the invention recited in Claim 6 because the cited references fail to depict a generation laser beam and detection laser beam that share a common optical path, and that use the generation and detection laser beam to assess the internal structure of the remote target. Further, Maris teaches an ultrafast optical technique for the characterization of altered semiconductor samples with implanted species. This depends on “change in reflected intensity; (b) a change in transmitted intensity; (c) a change in a polarization state of the reflected and/or transmitted light; (d) a change in the optical phase of the reflected and/or transmitted light; (e) a change in direction of the reflected and/or transmitted light; and (f) a change in optical path length between the sample's surface and a detector.” (Maris, Abstract)

Klien teaches away from the claimed invention. Klien does not require that the first and second beam illuminate substantially the same location on the surface of the target. The invention, as claimed in amended Claim 4 from which Claim 6 depends, requires that the first and second beam illuminate substantially the same location on the surface. Maris teaches the use of a wavelength of light to measure whether chemical species have been implanted within the sample. Maris examines the presence or absence of implant-related damage. One would not apply such teachings to the assessment of the internal structure of composite materials.

Applicants, therefore, respectfully request the Examiner to reconsider and withdraw the rejection to allow Claim 6.

Claims 9, 11-13, 15, 17, and 18 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Monchalin et al (US 5,080,491). The examiner states:

Monchalin et al (Monchalin hereinafter) show a laser optical ultrasound detection using two interferometers comprising:

a detection laser to generate a pulsed laser beam to detect the ultrasonic surface displacements on the surface of the remote target; collection optics for collecting phase modulated light from the pulsed laser beam either reflected or scattered by the remote target;

an interferometer to process the phase modulated light collected by the collection optics; said interferometer comprising: a first cavity (97) having a first confocal lens structure; a second cavity (99) having a second confocal lens structure; a device (91, 93) for dividing incoming depolarized light into a first polarized light component and a second polarized light component wherein said device also directs said first and second polarized light components into the first and second cavities;

a control system (117, 119) to adjust said First and second cavities such that a ratio of light transmitted through each cavity to light reflected back through each cavity remains substantially constant.

Monchalin does not expressly show the process but shows the light transmitted through the first cavity, the light reflected back through the first cavity, the light transmitted through the second cavity, and the light reflected back through the second cavity, all in order to obtain data representative of the ultrasonic surface displacements on the surface of the remote target. Processors are well known and at the time of the invention, one of ordinary skill in the art would have used a processor to analyze the signals.

With regards to the moving of the laser or the sample of claims 11, 12, and 17, it is well known to move either the sample or the target in order to scan the sample completely rather than just a single spot, and one of ordinary skill would have done so in order to evaluate the whole sample.

Applicants respectfully submit that Monchalin fails to:

“provide the ability to perform with high signal-to-noise-ratios (SNR) at large distances from typically very dark composite materials using small

aperture high-speed optical scanning methods. The ability to operate in such a mode has the distinct advantage of increasing the optical scan area coverage and providing substantially improved depth-of-field thereby eliminating the need for active focusing mechanisms.

[Monchalin does] not possess the desirable feature of removing common-mode noise from the laser signals using a fully self-referenced interferometric configuration that uses all of the available light without the use of separate stabilization measurements.

Another limitation associated with ... Monchalin and other known apparatuses relates to their inability to operate at very high scan rates and process ultrasonic data in real-time. This limitation makes such apparatuses only marginally useful for testing and evaluating composite materials.” (10/634,342, Page 4., Line 8 – Page 5, Line 13)

Additionally, Monchalin uses a portion of the detection laser to stabilize the interferometer. Applicants’ invention is stabilized using only the phase modulated light collected by the collection optics. (10/634,342, Page 19, lines 25-29) This increases the over all signal-to-noise ratio (SNR) of the output signal of the interferometer by eliminating the need for a portion of the detection signal to be used to stabilize the interferometer.

Applicants respectfully submit that the scanning assembly of amended Claims 9 and 15 facilitate high-speed optical scanning which Monchalin is incapable of. Applicants respectfully traverse the examiners assertion that “the moving of the laser or the sample of claims 11, 12, and 17, it is well known to move either the sample or the target in order to scan the sample completely rather than just a single spot, and one of ordinary skill would have done so in order to evaluate the whole sample.” The scanning assembly of amended Claims 9 and 15 redirects the laser to scan the sample spot across the target. This method does not involve the repositioning of the laser or sample but rather the redirection of the laser beam. This scanning ability is augmented with the positioning apparatus of Claims 11 and 17 to facilitate high-speed optical scanning.

Applicants, therefore, respectfully request the Examiner to reconsider and withdraw the rejection to allow Claims 9, 11-13, 15, 17, and 18.

Claim 10 and 16 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Monchalin as applied to claim 9 and 15 above, further in view of Siu et al. The examiner states:

Monchalin does not expressly show the intensity controller. Siu et al show ultrasonic evaluation system comprising a controlled pulsed laser. At the time of the invention, one of ordinary skill in the art would have used a controller for the laser in order to control the magnitude and pulse of the laser.

Applicants respectfully submit that there is no motivation, teaching or suggestion to combine Monchalin with Siu. Therefore, the rejection on a combination of these references is inappropriate. Withdrawal of the rejection allowance of Claims 10 and 16 is respectfully requested.

Applicants further submit that neither Monchalin or Siu alone nor the combination of the two teaches or suggests make obvious the invention recited in Claims 10 and 16 because the cited references fail to teach that control of the pulsed detection laser. Rather, Siu teaches that the power of the laser used to generate the ultrasound may be controlled. This is done “to prevent material ablation” (Siu, Col. 6, Lines 33-34) The present invention adjusts the detection laser to improve the received signal. Siu teaches that the generation laser may be adjusted to prevent material ablation, while the applicant claims that the detection laser may be adjusted to improve the received signal. Therefore, the cited prior art fails to mention any such arrangement.

Applicants, therefore, respectfully request the Examiner to reconsider and withdraw the rejection to allow Claim 10 and 16.

Claims 14 and 19 stand rejected under 35 U.S.C. 103 (a) as being unpatentable over White et al (US 6,128,081). The examiner states:

White et al show a method and system for measuring a physical parameter wherein the generation laser and the detection laser coaxially apply laser beams to the surface of the remote target. White et al does not show the interferometer comprising: a first cavity (97) having a first confocal lens structure; a second cavity (99) having a second confocal lens structure; a device

(91, 93) for dividing incoming de-polarized light into a first polarized light component and a second polarized light component wherein said device also

directs said first and second polarized light components into the first and second cavities.

Monchalin shows an interferometer used for measuring the surface characteristics comprising: an interferometer to process the phase modulated light collected by the collection optics; said interferometer comprising: a first cavity (97) having a first confocal lens structure; a second cavity (99) having a second confocal lens structure; a device (91, 93) for dividing incoming depolarized light into a first polarized light component and a second polarized light component wherein said device also directs said first and second polarized light components into the first and second cavities; a control system (117, 119) to adjust said first and second cavity such that a ratio of light transmitted through each cavity to light reflected back through each cavity remains substantially constant.

Monchalin does not expressly show the process but shows the light transmitted through the first cavity, the light reflected back through the first cavity, the light transmitted through the second cavity, and the light reflected back through the second cavity, all in order to obtain data representative of the ultrasonic surface displacements on the surface of the remote target. Processors are well known and at the time of the invention, one of ordinary skill in the art would have used a processor to analyze the signals.

At the time of the invention, one of ordinary skill in the art would have modified White et al to use the interferometer of Monchalin in order to allow ultrasound detection that is immune from intensity fluctuations of the laser and perturbations on the object surface (Abstract).

Applicants respectfully submit that Monchalin fails to:

“provide the ability to perform with high signal-to-noise-ratios (SNR) at large distances from typically very dark composite materials using small aperture high-speed optical scanning methods. The ability to operate in such a mode has the distinct advantage of increasing the optical scan area coverage and providing substantially improved

depth-of-field thereby eliminating the need for active focusing mechanisms.

[Monchalin does] not possess the desirable feature of removing common-mode noise from the laser signals using a fully self-referenced interferometric configuration that uses all of the available light without the use of separate stabilization measurements.

Another limitation associated with ... Monchalin and other known apparatuses relates to their inability to operate at very high scan rates and process ultrasonic data in real-time. This limitation makes such apparatuses only marginally useful for testing and evaluating composite materials.” (10/634,342, Page 4, Line 8 – Page 5, Line 13)

Additionally, Monchalin and White each use a portion of the detection laser to stabilize the interferometer. Applicants’ invention is stabilized using only the phase modulated light collected by the collection optics. (10/634,342, Page 19, lines 25-29) This increases the overall signal-to-noise ratio (SNR) of the output signal of the interferometer by eliminating the need for a portion of the detection signal to be used to stabilize the interferometer.

Applicants respectfully submit that there is no motivation, teaching or suggestion to combine Monchalin with White. Therefore, the rejection on a combination of these references is inappropriate. Withdrawal of the rejection allowance of Claims 14 and 19 is respectfully requested.

Neither Monchalin or White is capable of scanning a remote target. The scanning assembly of amended Claims 9 and 15 optically scans the laser sample spot across the target. This scanning ability is augmented with the positioning apparatus of Claim 11 and 17 to facilitate high-speed optical scanning.

Applicants, therefore, respectfully request the Examiner to reconsider and withdraw the rejection to allow Claims 14 and 19.